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MEMORANDUM FOR: See Distribution

The American Academy of Arts and Sciences has established a Commission on the Year 2000. It is an effort to indicate the future consequences of present public policy decisions, to anticipate future problems, etc. The attached list is from one of the series of papers in an initial report of the Commission published in Daedalus in the summer of 1967. This list of likely innovations may suggest some goals or objectives which should be included in the Agency's R&D program in the near future.

STAT

Special Assistant to the
DD/S&T

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tion.") In any case, Late Sensate culture carries implications of cosmopolitanism and pacifism and lack of particularist ethics or loyalties, except on a shifting, contractual basis. Nevertheless, it is probably safe to argue that over the next thirty-three years nationalism will increase in most of the underdeveloped and developing worlds, at least in the minimal sense that modern systems of public education and mass communication will integrate even the most peripheral groups into the common language and culture.

Science and Technology

In order to provide a quick impression of science and technology (with an emphasis on technology) in the last third of the twentieth century, we list one hundred areas in which technological innovation will almost certainly occur.

Each item is important enough to make, by itself, a significant change. The difference might lie mainly in being spectacular (for example, transoceanic rocket transportation in twenty or thirty minutes, rather than supersonic in two or three hours); in being ubiquitous (widespread use of paper clothes); in enabling a large number of different things to be done (super materials); in effecting a general and significant increase in productivity (cybernation); or simply in being important to specific individuals (convenient artificial kidneys). It could be argued reasonably that each of these warrants the description technological innovation, revolution, or breakthrough. None is merely an obvious minor improvement on what currently exists.

We should note that the one hundred areas are not ordered randomly. Most people would consider the first twenty-five unambiguous examples of progress. A few would question even these, since lasers and masers, for example, might make possible a particularly effective ballistic missile defense and, thus, accelerate the Soviet-American arms race. Similarly, the expansion of tropical agriculture and forestry could mean a geographical shift in economic and military power, as well as a dislocation of competitive industries. Nevertheless, there probably would be a consensus among readers that the first twenty-five areas do represent progress—at least for those who are in favor of "progress."

The next twenty-five areas are clearly controversial; many would argue that government policy might better restrain or discourage innovation or diffusion here. These "controversial areas"

raise issues of accelerated nuclear proliferation, loss of privacy, excessive governmental or private power over individuals, dangerously vulnerable, deceptive, and degradable overcentralization, inherently dangerous new capabilities, change too cataclysmic for smooth adjustment, or decisions that are inescapable, yet at the same time too complex and far-reaching to be safely trusted to anyone's individual or collective judgment.

The last fifty items are included because they are intrinsically interesting and to demonstrate that a list of one hundred items of "almost certain" and "very significant" innovation can be produced fairly easily.[8]

One Hundred Technical Innovations Likely in the Next Thirty-Three Years

1. Multiple applications of lasers and masers for sensing, measuring, communicating, cutting, heating, welding, power transmission, illumination, destructive (defensive), and other purposes
2. Extremely high-strength or high-temperature structural materials
3. New or improved super-performance fabrics (papers, fibers, and plastics)
4. New or improved materials for equipment and appliances (plastics, glasses, alloys, ceramics, intermetallics, and cermets)
5. New airborne vehicles (ground-effect machines, VTOL and STOL, superhelicopters, giant supersonic jets)
6. Extensive commercial application of shaped charges
7. More reliable and longer-range weather forecasting
8. Intensive or extensive expansion of tropical agriculture and forestry
9. New sources of power for fixed installations (for example, magnetohydrodynamic, thermionic, and thermoelectric, radioactive)
10. New sources of power for ground transportation (storage-battery, fuel-cell propulsion or support by electromagnetic fields, jet engine, turbine)
11. Extensive and intensive world-wide use of high-altitude cameras for mapping, prospecting, census, land use, and geological investigations
12. New methods of water transportation (large submarines, flexible and special-purpose "container ships," more extensive use of large automated single-purpose bulk cargo ships)

13. Major reduction in hereditary and congenital defects
14. Extensive use of cyborg techniques (mechanical aids or substitutes for human organs, sense, limbs)
15. New techniques for preserving or improving the environment
16. Relatively effective appetite and weight control
17. New techniques in adult education
18. New improved plants and animals
19. Human "hibernation" for short periods (hours or days) for medical purposes
20. Inexpensive "one of a kind" design and procurement through use of computerized analysis and automated production
21. Controlled super-effective relaxation and sleep
22. More sophisticated architectural engineering (geodesic domes, thin shells, pressurized skins, esoteric materials)
23. New or improved uses of the oceans (mining, extraction of minerals, controlled "farming," source of energy)
24. Three-dimensional photography, illustrations, movies, and television
25. Automated or more mechanized housekeeping and home maintenance
26. Widespread use of nuclear reactors for power
27. Use of nuclear explosives for excavation and mining, generation of power, creation of high-temperature/high-pressure environments, or for a source of neutrons or other radiation
28. General use of automation and cybernation in management and production
29. Extensive and intensive centralization (or automatic interconnection) of current and past personal and business information in high-speed data processors
30. Other new and possibly pervasive techniques for surveillance, monitoring, and control of individuals and organizations
31. Some control of weather or climate
32. Other (permanent or temporary) changes or experiments with the over-all environment (for example, the "permanent" increase in C-14 and temporary creation of other radioactivity by nuclear explosions, the increasing generation of CO_2 in the atmosphere, projects Starfire, West Ford, Storm Fury, and so forth)
33. New and more reliable "educational" and propaganda techniques for affecting human behavior—public and private

34. Practical use of direct electronic communication with and stimulation of the brain
35. Human hibernation for relatively extensive periods (months to years)
36. Cheap and widely available or excessively destructive central war weapons and weapons systems
37. New and relatively effective counterinsurgency techniques (and perhaps also insurgency techniques)
38. New kinds of very cheap, convenient, and reliable birth-control techniques
39. New, more varied, and more reliable drugs for control of fatigue, relaxation, alertness, mood, personality, perceptions, and fantasies
40. Capability to choose the sex of unborn children
41. Improved capability to "change" sex
42. Other genetic control or influence over the "basic constitution" of an individual
43. New techniques in the education of children
44. General and substantial increase in life expectancy, postponement of aging, and limited rejuvenation
45. Generally acceptable and competitive synthetic foods and beverages (carbohydrates, fats, proteins, enzymes, vitamins, coffee, tea, cocoa, liquor)
46. "High quality" medical care for underdeveloped areas (for example, use of referral hospitals, broad-spectrum antibiotics, artificial blood plasma)
47. Design and extensive use of responsive and super-controlled environments for private and public use (for pleasurable, educational, and vocational purposes)
48. "Nonharmful" methods of "overindulging"
49. Simple techniques for extensive and "permanent" cosmetological changes (features, "figures," perhaps complexion, skin color, even physique)
50. More extensive use of transplantation of human organs
51. Permanent manned satellite and lunar installations—interplanetary travel
52. Application of space life systems or similar techniques to terrestrial installations
53. Permanent inhabited undersea installations and perhaps even colonies

54. Automated grocery and department stores
55. Extensive use of robots and machines "slaved" to humans
56. New uses of underground tunnels for private and public transportation
57. Automated universal (real time) credit, audit, and banking systems
58. Chemical methods for improved memory and learning
59. Greater use of underground buildings
60. New and improved materials and equipment for buildings and interiors (variable transmission glass, heating and cooling by thermoelectric effect, electroluminescent and phosphorescent lighting)
61. Widespread use of cryogenics
62. Improved chemical control of some mental illness and some aspects of senility
63. Mechanical and chemical methods for improving human analytical ability more or less directly
64. Inexpensive and rapid techniques for making tunnels and underground cavities in earth or rock
65. Major improvements in earth moving and construction equipment generally
66. New techniques for keeping physically fit or acquiring physical skills
67. Commercial extraction of oil from shale
68. Recoverable boosters for economic [illegible]ce launching
69. Individual flying platforms
70. Simple inexpensive video recording and playing
71. Inexpensive high-capacity, world-wide, regional, and local (home and business) communication (using satellites, lasers, light pipes, and so forth)
72. Practical home and business use of "wired" video communication for both telephone and television (possibly including retrieval of taped material from libraries or other sources) and rapid transmission and reception of facsimiles (possibly including news, library material, commercial announcements, instantaneous mail delivery, other printouts)
73. Practical large-scale desalinization
74. Pervasive business use of computers for the storage, processing, and retrieval of information

75. Shared-time (public and interconnected) computers generally available to home and business on a metered basis
76. Other widespread use of computers for intellectual and professional assistance (translation, teaching, literary research, medical diagnosis, traffic control, crime detection, computation, design, analysis, and, to some degree, as a general intellectual collaborator)
77. General availability of inexpensive transuranic and other esoteric elements
78. Space defense systems
79. Inexpensive and reasonably effective ground-based ballistic missile defense
80. Very low-cost buildings for home and business use
81. Personal "pagers" (perhaps even two-way pocket phones) and other personal electronic equipment for communication, computing, and data-processing)
82. Direct broadcasts from satellites to home receivers
83. Inexpensive (less than $20), long-lasting, very small, battery-operated television receivers
84. Home computers to "run" the household and communicate with outside world
85. Maintenance-free, long-life electronic and other equipment
86. Home education via video and computerized and programmed learning
87. Programmed dreams
88. Inexpensive (less than 1 cent a page) rapid, high-quality black and white reproduction; followed by colored, highly detailed photography reproduction
89. Widespread use of improved fluid amplifiers
90. Conference television (both closed-circuit and public communication systems)
91. Flexible penology without necessarily using prisons (by use of modern methods of surveillance, monitoring, and control)
92. Common use of individual power source for lights, appliances, and machines
93. Inexpensive world-wide transportation of humans and cargo
94. Inexpensive road-free (and facility-free) transportation
95. New methods for teaching languages rapidly

97. New biological and chemical methods to identify, trace, incapacitate, or annoy people for police and military uses
98. New and possibly very simple methods for lethal biological and chemical warfare
99. Artificial moons and other methods of lighting large areas at night
100. Extensive use of "biological processes" in the extraction and processing of minerals

World-wide Industrialization, Affluence, and Population Growth

Many people—Kenneth Boulding, Peter Drucker, and John Maynard Keynes, for example—have pointed out that until the last two or three centuries no large human society had ever produced more than the equivalent of $200 per capita annually. With industrialization, mankind broke out of this pattern. By the end of this century, we expect that the nations of the world might be divided into the following five classes:

1. Preindustrial	$50 to $200 per capita
2. Partially industrialized or transitional	$200 to $600 per capita
3. Industrial	$600 to perhaps $1,500 per capita
4. Mass-consumption or advanced industrial	Perhaps $1,500 to something more than $4,000 per capita
5. Postindustrial	Something over $4,000 to $16,000 per capita

We shall consider partially industrialized societies as being in a transition stage, without assuming that they will necessarily continue to industrialize. Those countries we call industrialized are roughly in the condition of interwar America or postwar Europe.

Many preindustrial or partially industrialized societies may also, of course, have dual economies—for example, northern and southern Italy. This problem, now defined in terms of urban and rural differences, may, by the year 2000, be most critical in the six most populous, least developed countries: China, India, Pakistan, Indonesia, Brazil, and Nigeria. These now contain, and in the future will probably continue to contain, about half of the world's

population; they are now preindustrial, but presumably will be partially industrialized by the end of the century.

Problems caused by great development in major cities and less in lesser cities and rural areas are already evident in these countries. Despite important differences in average development, one can argue that most great cities today have achieved startlingly similar conditions of modernization, and are at least "twentieth century." Rio de Janeiro, Bangkok, and Athens have many of the virtues and problems of the major cities of the United States: twentieth-century slums, computers, labor displaced by automation, great universities, skilled craftsmen, a trend toward tertiary and quaternary occupations, startlingly similar price structures for many commodities and activities.

The post-World War II period has seen the emergence of the mass-consumption society, first in the United States and then in Western Europe and Japan. Japan, although it has less than $1,000 per capita, is by every superficial appearance a mass-consumption society today, while the Soviet Union, with a per-capita income of around $1,500, seems far short of that condition. Similarly $4,000 per capita will probably be sufficient for transition to a postindustrial economy for the Scandinavian countries or Great Britain, while countries with more ambitious goals in terms of world power (the U.S.S.R.), stronger traditions of economic striving (West Germany), or higher expectations of productive affluence (the U. S.) will not become postindustrial until higher levels of affluence have been reached.

The chart below indicates a rather impressionistic, but not wholly unreasonable economic ranking for the nations of the world in the year 2000. The figures express national populations in millions, and the total world population is estimated at 6.4 billion. On the whole, the descriptions are optimistic, but we would not care to defend in detail the specific rank order we have suggested. The numbers identifying each group correspond roughly to the levels of income of the previous table.

If this scenario is realized, the year 2000 will find a rather large island of wealth surrounded by "misery"—at least relative to the developed world and to "rising expectations." But even the poor countries will, for the most part, enjoy great improvements over their traditional standards of living. The postindustrial and industrial societies will contain about 40 per cent of the world's population, and more than 90 per cent of the world's population